by him as Æcidium,[2] and from Ocean Springs, Mississippi, where one of the present writers discovered its true gymnosporangial character, and also its peculiar rœstelia, in 1892. The Mississippi material was first collected in January 1887 and sent to Professor Farlow, so that Mississippi is one of the type localities of the original description. Later in the spring of 1892 the teleutospores were discovered, and in October of the same year the rœstelia with its distinct, long exserted, lacerate peridia was found on the same galls, the old broken bases of which must have formed the peridia of the supposed Æcidium as originally described. The species, therefore, unlike all its congeners, produces its æcidial and teleutosporic stages on the same host, from the same gall, and in all probability from the same mycelium. The species can scarcely be said to be common, though when found it usually infests considerable portions of the tree in which it occurs. Several stations are now known for the parasite at distances of a few miles from the original tree where it was found in 1887.

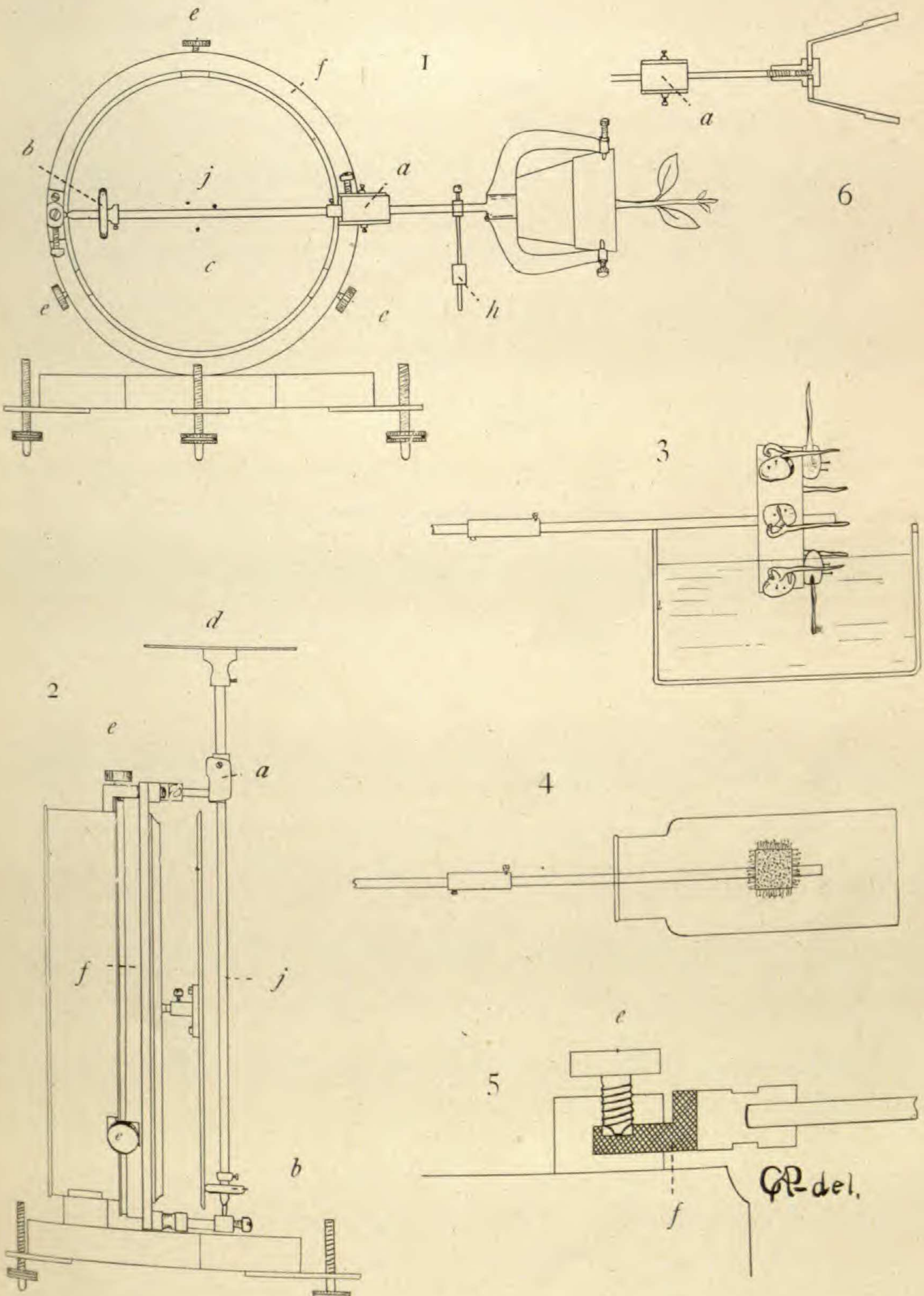
The conditions of growth manifested by the last species introduce a new and interesting problem into the question of the evolution of the various species of the genus. At one extreme of the series we have *G. macropus* and its new ally, annual species, producing their rœstelias on various Pomaceæ and consequently dependent for their perpetuity upon the success of their annual sowing and interchange of host. Then we have the various species that are perennial and thus capable of continuing from year to year without the intervention of the rœstelia stage, but with which they continue to propagate themselves more widely. Then, finally, we have *G. Bermudianum* producing both stages on the same host and therefore independent of the Pomaceæ for its continuance. The details of this evolution will constitute a further problem.— LUCIEN M. UNDERWOOD and F. S. EARLE, *Auburn, Alabama.*

BOTANICAL APPLIANCES.

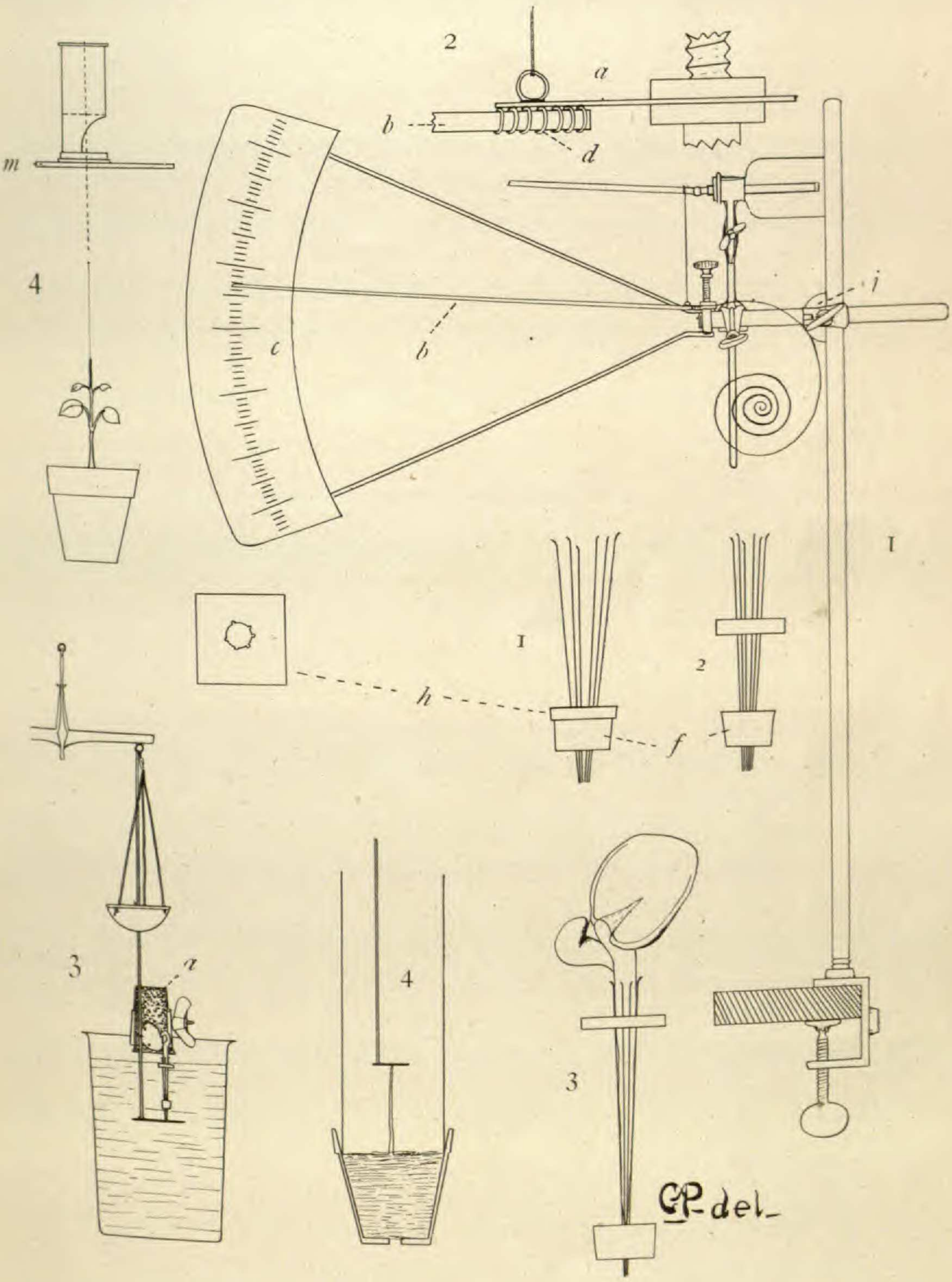
(WITH PLATES IX AND X.)

BOTANICAL appliances serve for investigation and demonstration, and while some of the following appliances were devised for special work they have also been used in demonstration in a practical course of vegetable physiology in our laboratory.

[2] *Æcidium Bermudianum* Farlow, BOT. GAZ. 12:206. 1887.



STONE on a CLINOSTAT.



STONE on BOTANICAL APPLIANCES.

Clinostat (*pl. IX*).—The phenomena of heliotropism and geotropism are of such fundamental importance that I believe it would not be out of place to offer demonstrations of them in secondary schools, especially since our elementary text-books lay some stress on plant physiology. It was partially with this idea that this instrument was devised, and in its construction we have endeavored to obtain a cheap and compact piece of apparatus, and one at the same time which will illustrate all of the principles. Undoubtedly the best clinostat which has been devised for general purposes is that of Pfeffer, made by Albrecht of Tübingen at a cost of $80. It can be adjusted to different rates of speed and is furnished with a powerful spring which enables it to run twenty-four hours without rewinding. An excellent clinostat is that of Wortmann, made at Strassburg, and costing about $60. So far as compactness is concerned this is the best, but a great drawback is that it has to be wound every twelve hours. Every laboratory where plant physiology is taught should endeavor to have one of the above, but when it is necessary to have more than one, or in case an instrument for illustrative purposes only is needed, a simpler and cheaper one will frequently answer as well. Such an instrument I have used in modified forms for three years. Briefly stated, it consists of an eight-day spring Waterbury clock (*figs. 1* and *2*) with a disk attached to the hour hand spindle which moves a shaft provided with a small friction wheel to which the plants are attached. The disk (*c*) is of aluminum 2^{mm} thick and 47^{mm} in diameter, fastened to the hour hand spindle by means of a set screw. The hour hand spindle is lengthened to extend beyond the face of the clock, and is larger and provided with a better bearing than is ordinarily supplied with the clock by dealers. This gives to the movement greater stability, although I have used the ordinary spindle with success. Shortening the hair spring of the balance wheel of the clock causes the hour hand spindle, and consequently the aluminum disk, to make a revolution every half hour.

In front of the disk there is a steel rod shaft (*j*) which runs on a point at the base and in an elongated bearing at the top and is provided with a swivel joint to prevent lateral friction. On this steel rod and at right angles to the disk there is a small brass wheel (*b*) 23^{mm} in diameter covered with a solid rubber ring, a tire, which is in direct contact with the disk. This wheel constitutes a friction wheel and revolves when in contact with the aluminum disk. It can be moved by means of a set screw to any position on the rod required, thus enabling one to modify the speed.

If, for example, the friction wheel be placed upon the shaft near the center of the disk, the speed is retarded; if, on the contrary, it is placed near the circumference, then the speed is accelerated. When the friction wheel is 23^{mm} from the center of the disk, the small shaft revolves once every half hour, at a distance of 46^{mm} from the center it revolves every fifteen minutes, and when at 69^{mm} it revolves in seven and one-half minutes. In fact any degree of speed can be obtained between seven and one-half and thirty minutes. Should it be necessary to obtain a higher speed a smaller friction wheel can be used, or the hair spring can be shortened still further. *Fig. 2* shows a side view of the clinostat when set up for the purpose of eliminating the effects of light, the plants being placed upon the horizontal disk (*d*). In *figs. 1, 3, 4,* and *5* the instrument is shown when in use for gravity experiments. In the latter instance the steel rod is placed horizontally. The apparatus is so arranged that any angle can be obtained. This is accomplished by means of three set screws (*e*) which are attached to the clock and fit into depressions in the metal rim (*f*) which is movable. This mechanism is shown more in detail in the enlarged cross-section of *fig. 5*, the metal rim being represented by the shaded portion. By loosening the three set screws (*e*) the rim can be revolved, and as the shaft attachments are connected with the rim they move with it. In *fig. 1* a holder is attached to the end of the shaft for the purpose of carrying the plant. The pot used is 2^{in} in diameter, and is centered and held in place by means of three screws. A simpler method of holding the plant is shown in *fig. 6*, where the end of the shaft is made to pass through a hole in the bottom of the pot, the pot being securely held in place by means of a double flange. The shaft is also provided with a balance wheel (*h*). In order that the plant may be balanced it is only necessary to remove the friction wheel from the disk, which allows the shaft to revolve freely, then adjust the compensating weight (*h*), bringing the center of gravity of the pot within that of the shaft. Instead of using a growing plant in the pot, grass nodes, or flower stalks, can be readily substituted. For eliminating the effect of gravity in roots the apparatus is set up as shown in *fig. 2*, in which case the roots are kept from drying up by revolving in a dish of water.

For Phycomyces or Mucor it can be conveniently arranged as in *fig. 4*, in which case the shaft is elongated. The clinostat is mounted on a wooden base provided with three leveling screws and will run four days without winding. It is made especially for light objects although I have carried fourteen pounds on it in a horizontal position for a number of hours. The apparatus could be constructed, I suppose, for about $15.

Spring dynamometer (*pl. X, figs. 1* and *2*).—This apparatus was devised for the purpose of measuring the power of growth induced by geotropism in grass nodes. It consists of a watch spring (*a*) having attached to its end a straw (*b*) which amplifies the movement on the graduated scale of the arc (*c*). The straw is held securely by means of a spiral wire (*d*) soldered to the underside of the spring, allowing the straw to be removed at leisure. Directly above this straw is a wire loop for attaching a thread, the other end of which is fastened to the grass culm at a distance from the node of ½^{in}. The grass culm has its lower end inserted in a bottle containing water provided with a perforated cork through which is placed a glass tube tightly fitting the culm, thus holding it securely. The bottle is supported by an Arthur clamp and is mounted on a vertical rod which can be adjusted to any desired angle by a unique joint (*j*) made by the O. C. White Company, Worcester, Mass. By lengthening or shortening the spring the tension can be readily varied. In the illustration the whole watch spring is shown, but of course only a short piece is necessary.

Apparatus for measuring and recording root-growth (*pl. X, fig. 3*).—Having had occasion in my experiments to record the hourly increments of growth in the length of a large number of roots I was obliged to devise a self-regulating apparatus for this purpose. So far as I am aware no self-registering appliance has been employed in the growth of roots. The method in general use consists in direct readings with a horizontal microscope. Any one who has employed this method must be aware that it is exceedingly tedious, and, moreover, that it is not accurate on account of the nutation of the root, which under high magnification is liable to give rise to serious errors in the readings. The root constitutes one of the most delicate organs of a plant, and it is clear therefore that whatever apparatus we use must be of the most sensitive kind. It must be able to keep the root straight, yet allowing a certain amount of play; it must be constructed out of material which will not injure the root; and the apparatus which multiplies the growth must possess the least resistance possible.

In describing this apparatus it will not be necessary to go into the